

TITLE OF THE INVENTION

BUBBLE-JET TYPE INK-JET PRINthead

CLAIM OF PRIORITY

[0001] This application makes reference to, incorporates the same herein, and claims all benefits accruing under 35 U.S.C. §119 from my application entitled *BUBBLE-JET TYPE INK-JET PRINthead* filed with the Korean Industrial Property Office on 24 July 2000 and there duly assigned Serial No. 2000/42365.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to an ink-jet printhead, and more particularly, to a bubble-jet type ink-jet printhead.

Description of the Related Art

[0003] The ink ejection mechanisms of an ink-jet printer are largely categorized into two types: an electro-thermal transducer type (bubble-jet type) in which a heat source is employed to form a bubble in ink causing ink droplets to be ejected, and an electro-mechanical transducer type in which a piezoelectric crystal bends to change the volume of ink causing ink droplets to be expelled.

[0004] Meanwhile, a bubble-jet type ink-jet printhead having an ink ejector needs to meet the following conditions. First, a simplified manufacturing process, the low manufacturing cost, and

high volume production must be allowed. Second, to produce high quality color images, creation of small and minute satellite droplets that trail ejected main droplets must be prevented. Third, when ink is ejected from one nozzle or ink refills an ink chamber after ink ejection, cross-talk with adjacent nozzles from which no ink is ejected must be prevented. Fourth, for a high speed print, a cycle beginning with ink ejection and ending with ink refill must be as short as possible.

[0005] However, the above conditions tend to conflict with one another, and furthermore, the performance of an ink-jet printhead is closely related to the structures of an ink chamber, an ink channel, and a heater, the type of formation and expansion of bubbles associated therewith, and the relative size of each component.

[0006] In efforts to overcome problems related to the above requirements, ink-jet print heads having a variety of structures have been proposed in U. S. Patent Nos. 4,339,762; 4,882,595; 5,760,804; 4,847,630; and 5,850,241, European Patent No. 317,171, and Fan-Gang Tseng, Chang-Jin Kim, and Chih-Ming Ho, "A Novel Micoinjector with Virtual Chamber Neck", IEEE MEMS '98, pp. 57-62. However, ink-jet printheads proposed in the above patents and literature may only satisfy some of the aforementioned requirements but do not completely provide an improved ink-jet printing approach.

SUMMARY OF THE INVENTION

[0007] To solve the above problems, it is an objective of the present invention to provide a bubble-jet type ink-jet printhead having a structure for effectively preventing a back flow of ink.

[0008] It is another objective of the present invention to provide a bubble-jet type ink-jet printhead

1 in which an ink channel, along which ink flows, has a simple structure and ink is supplied smoothly.

2 **[0009]** It is still another objective of the present invention to provide a bubble-jet type ink-jet
3 printhead that allows for minute adjustment in an ink ejection amount and ejection of a fixed
4 amount.

5 **[0010]** It is yet still another objective of the present invention to provide a bubble-jet type ink-jet
6 printhead that allows for high-speed operation by shortening an ink refill time.

7 **[0011]** It is further an object of the present invention to provide an ink jet printhead that produces
8 uniform droplet size.

9 **[0012]** It is still further an object of the present invention to provide an ink jet ejection mechanism
10 that has two heater units for each nozzle hole;

11 **[0013]** It is also an object of the present invention to provide an ink chamber that can be filled
12 from two directions.

13 **[0014]** Accordingly, to achieve the above objectives, the present invention provides a bubble-jet
14 type ink jet printhead including a substrate, a plurality of chamber walls arranged parallel to one
15 another on the substrate for dividing a chamber into a plurality of unit chambers having a
16 predetermined height, which are ink flow areas, a bubble generating means, provided for each unit
17 chamber, which includes two unit heaters spaced apart by a predetermined distance on the substrate,
18 and a nozzle plate, combined above the substrate, in which a plurality of nozzles are formed, each
19 nozzle corresponding to a region between the two unit heaters of each bubble generating means. In
20 the ink-jet printhead, ink is supplied from both sides of the unit chamber.

21 **[0015]** Furthermore, the two unit heaters of each bubble generating means are electrically coupled

to each other. The two unit heaters may be integrated or spaced apart by a predetermined distance, between which an electrical connection member is disposed.

[0016] The opposite portions of the two unit heaters of the bubble generating means may be coupled to a common signal line and the exterior ends of the two unit heaters may be commonly coupled to one parallel connection member. Alternatively, the ends of one side of each bubble generating means are coupled to a serial connection member while the ends of the other side are coupled to electrical signal lines, respectively. The exterior ends of the two unit heaters of the bubble generating means may be connected to the parallel connection member integrated therewith, and the common signal line may be commonly coupled to the middle portions of a plurality of bubble generating means.

[0017] A first insulating layer may be disposed between the common signal line and the bubble generating means, and a contact hole for contacting the common signal line and a connection portion of both unit heaters of the bubble generating means may be formed in the first insulating layer. A second insulating layer may be formed on the uppermost surface of a stack structure including the bubble generating means and the chamber wall is formed on the second insulating layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or similar components, wherein:

1 **[0019]** FIGS. 1A and 1B are cross-sectional views showing the structure of a conventional bubble-
2 jet type ink-jet printhead along with ink ejection mechanism;

3 **[0020]** FIG. 2 is a schematic top view of a bubble-jet type ink-jet printhead according to an
4 embodiment of the present invention;

5 **[0021]** FIG. 3 is a cross-sectional view taken along line A - A of FIG. 2;

6 **[0022]** FIG. 4 is a cross-sectional view taken along line B - B of FIG. 2;

7 **[0023]** FIG. 5 is an extracted view showing the portion C of FIG. 2;

8 **[0024]** FIGS. 6 - 9B show an ink ejection process for a bubble-jet type ink-jet printhead according
9 to the present invention;

10 **[0025]** FIG. 10 is a top view showing the structure of a region around one unit chamber in the
11 bubble-jet type ink-jet printhead according to the present invention;

12 **[0026]** FIG. 11 is a cross-sectional view taken along line D - D of FIG. 10;

13 **[0027]** FIG. 12 is a cross-sectional view taken along line E - E of FIG. 10;

14 **[0028]** FIG. 13 illustrates a view of the electrical connections of a single bubble generator
15 according to a first embodiment of the present invention;

16 **[0029]** FIG. 14 illustrates a second embodiment of the present invention having a serial electrical
17 connection structure; and

18 **[0030]** FIGS. 15A - 15H show a process of forming a bubble generator applied to the bubble-jet
19 type ink-jet printhead according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Referring to FIGS. 1A and 1B, a bubble-jet type ink ejection mechanism will now be described. When a current pulse is applied to a heater 12 consisting of resistive heating elements located at an ink channel 10 where a nozzle 11 is formed, heat generated by the heater 12 boils ink 14 forming a bubble 15 within the ink channel 10, which causes an ink droplet 14' to be ejected. A back flow of ink in the opposite direction of a nozzle must be avoided during ink ejection. Another heater 13 in FIGS. 1A and 1B is provided for this purpose.

[0032] A heater is mainly shown in FIGS. 2 and 3, and components related thereto are omitted to aid in the understanding, and the detailed structure of the heater will be described separately. FIGS. 2 and 3 schematically show an ink-jet printhead having a structure in which nozzles 201 are arranged in two rows. Referring to FIGS. 2 and 3, a plurality of electrode pads 101 are arranged at predetermined intervals along both edges in the longitudinal direction of the substrate 100. A nozzle plate 200, in which the nozzles 200 are arranged in two rows, is disposed at the upper portion of the substrate 100. An isolation wall 102a extending from the middle portion of the substrate 100 in a longitudinal direction is disposed between the substrate 100 and the nozzle plate 200, and outer walls 102b are disposed along both edges in the longitudinal direction of the nozzle plate 200. Thus, an ink chamber 300 disposed between the substrate 100 and the nozzle plate 200 is partitioned into two, and ink is supplied to the ink chamber 300 through ink feed grooves 103 formed at both short sides of the substrate 100.

[0033] Meanwhile, a plurality of chamber walls 102c extending in a direction vertical to both outer walls 102b and the isolation wall 102a are arranged parallel to one another between each of

the outer walls 102b and the isolation wall 102a in a direction in which the outer walls 102b and the isolation wall 102a extend. Both ends of the chamber wall 102c are separated from the outer wall 102b and the isolation wall 102a by a predetermined space. A unit chamber 300a isolated by the chamber wall 102c is provided for each nozzle, and the unit chambers 300a are connected to one another through openings between the ends of the chamber walls 102c. Unit heaters 400a and 400b constituting a symmetrical bubble generator 400 are disposed at the lower portion of the unit chamber 300a. As will be described later, the two unit heaters 400a and 400b of the bubble generator 400 for each nozzle 201 or unit chamber 300a are electrically coupled to each other, and the heaters 400a and 400b may have either parallel or serial connection structure. Also, both unit heaters 400a and 400b are arranged in a straight line parallel to the chamber walls between the chamber walls 102c, and the heaters 400a and 400b generate the same thermal energy, which causes bubbles of the same size to be formed.

[0034] As shown in FIGS. 3 and 5 in detail, the nozzle 201 of the nozzle plate 200 is located at the upper center between the unit heaters 400a and 400b. Referring to FIG. 4, which is a cross-sectional view taken along line B-B of FIG. 2, the ink feed grooves 103 are disposed at both ends of the substrate 100. Reference numerals 500 and 501 denote a portion of an ink cartridge for storing ink and a sealing material for sealing the gap between the ink cartridge 500 and the nozzle plate 200.

[0035] An ink ejection process in the ink-jet printhead according to the present invention having a distinctive structure as described above will now be described. FIG. 6 shows a state in which ink fills the unit chamber 300a. Ink 600 is introduced from both sides of the unit chamber 300a. In this case, the ink 600 is filled by capillary action and gravity. FIG. 7 shows an early stage at which

1 bubbles are formed at a region in contact with the unit heaters 400a and 400b upon application of
2 a voltage pulse to the unit heaters 400a and 400b of the bubble generator 400. In this case, bubbles
3 600b are generated by the unit heaters 400a and 400b disposed on both sides of a central axis that
4 passes through the nozzle 201. As the bubbles 600b expand, pressure is applied to the ink 600
5 present between the bubbles 600b and the ink 600 on the outside thereof, causing a back flow of a
6 small amount of ink 600.

7 **[0036]** FIG. 8 shows a state in which the bubbles 600b formed by the unit heaters 400a and 400b
8 expand so that a region between the bubbles 600b is closed as a voltage pulse continues to be applied
9 to the unit heaters 400a and 400b of the bubble generator 400. Thus, the ink 600 present in the
10 closed region by the bubbles 600b, that is, a region below the nozzle 201, begins to be ejected
11 through the nozzle 201 by force applied by the expansion of the bubbles 600b.

12 **[0037]** FIG. 9A is a top view showing a state in which the bubbles 600b generated by the unit
13 heaters 400a and 400b reach their maximum growth as application of a voltage pulse to the unit
14 heaters 400a and 400b of the bubble generator 400 continues to complete ejection of the ink 600
15 present in the closed region between the bubbles 600b through the nozzle 201, and FIG. 9B is a side
16 view showing the same state.

17 **[0038]** As shown in FIGS. 9A and 9B, the bubbles 600b fully expanded by the unit heaters 400a
18 and 400b cause the ink 600 between the bubbles 600b to be ejected in droplets 600a. At the same
19 time that ejection of the droplet 600a is complete in this way, a voltage ceases to be applied to the
20 unit heaters 400a and 400b of the bubble generator 400 and hence the bubbles 600b that have
21 reached maximum growth collapse and the ink 600 begins to refill. Thus, the process returns to an

1 initial state shown in FIG. 5.

2 **[0039]** The structural features of the ink-jet printhead according to the present invention that ejects
3 ink droplet through the above process are to include an isolated unit chamber provided for each
4 nozzle and a bubble generator consisting of unit heaters disposed on both sides of the nozzle. Due
5 to the structural features, as both bubbles generated by both unit heaters grow, ink below the nozzle
6 is separated or isolated from the ink on the outside of the bubbles, thus preventing a back flow of the
7 ink present below the nozzle. Furthermore, the ink below the nozzle is isolated by both bubbles and
8 sufficient pressure is exerted on the ink, so as to generate a droplet which will be ejected with high
9 pressure. Further, due to the structural features, it is possible to minutely adjust the size of a droplet
10 ejected depending on the amount of heat generated by the bubble generator. The ink-jet printhead
11 according to the present invention includes an ink channel having a simple structure unlike a
12 conventional printhead, thereby effectively preventing the clogging of an ink channel due to foreign
13 materials or the occurrence of cross-talk with adjacent regions.

14 **[0040]** The detailed structure of the heaters 400a and 400b will now be described. FIG. 10 is a
15 top view showing the arrangement structure of a portion around the unit chamber 300a. 601 and 602
16 denote insulating layers for insulating signal lines 101a and 101a' connected to the bubble generator
17 400 from each other. First, referring to FIGS. 10 and 11, the two unit heaters 400a and 400b of the
18 bubble generator 400 unite into a single body, the middle portion of which is in contact with the
19 common signal line 101a' coupled to the common electrode pad 101'. Thus, a resistance component
20 at the portion in contact with the common signal line 101a' is shorted out of the circuit by the
21 common signal line 101a' and hence both unit heaters 400a and 400b are connected in series by the

common signal line 101a'. The common signal line 101a' is coupled to another bubble generator 400 as well. Further, the first insulating layer 601 is formed at a portion excluding the common signal line 101a' in the middle portion of the bubble generator 400, while the second insulating layer 602 is formed over the common signal line 101a' and the bubble generator 400.

[0041] FIG. 13 illustrates a view of the electrical connections of a single bubble generator according to the first embodiment of the present invention. Meanwhile, as shown in FIG. 13, a parallel connector 401, which is integrated with the bubble generator 400 and electrically connected to both ends of the bubble generator 400, is formed on one side of the bubble generator 400, on top of which an individual signal line 101a is formed. The individual signal line 101a extends longitudinally to be connected to the electrode pad 101. The individual signal line 101a and the electrode pad 101 are integrated with each other and formed on the parallel connector 401 consisting of resistors thus removing resistance component of the parallel connector 401 by an electrical short.

[0042] As shown in FIG. 12, the first insulating layer 601 is interposed between the parallel connector 401 and the common signal line 101a', thereby electrically separating the parallel connector 401 and individual signal line 101a from the common signal line 101a'. The second insulating layer 602 is positioned on the uppermost surface of the stack structure thereby protecting the unit heaters 400a and 400b of the bubble generator 400 from ink. The chamber wall 102c, the top surface of which contacts the bottom of the nozzle plate 200, is formed on the second insulating layer 602 with a predetermined height.

[0043] In the bubble generator 400 and a peripheral structure associated therewith, the unit heaters 400a and 400b of the bubble generator 400 are electrically coupled to each other in parallel between

1 the common signal line 101a' and the individual signal line 101a formed on the parallel connector
2 401. The parallel connection structure may be modified to a serial connection structure by
3 appropriate arrangement of the signal lines. FIG. 14 illustrates a second embodiment of the present
4 invention having this serial connection structure. In this case, as shown in FIG. 14, both unit heaters
5 400a and 400b of the bubble generator 400 are separated from each other, between which a serial
6 connection unit 101b is interposed. Also, the outer portions of the unit heaters 400a and 400b may
7 be coupled to a common signal line 101' and an individual signal line 101, respectively. In this case,
8 the unit heaters 400a and 400b may be integrally connected and the serial connector 101b stacked
9 on the middle portion of the integrated unit heater 400a and 400b corresponding to a nozzle, thereby
10 obtaining the same serial connection effect.

11 **[0044]** The serial connector 101b can be applied to the bubble generator 400 shown in FIGS. 10 -
12 13. In this case, the unit heaters 400a and 400b integrally formed are separated and the serial
13 connector 101b is interposed between the unit heaters 400a and 400b. The common signal line 101a'
14 is connected to the serial connector 101b.

15 **[0045]** To aid in the understanding on the structures of the bubble generator 400 shown in FIGS.
16 10 - 13 and the bubble generator shown in FIG. 14, which is an applied example of the bubble
17 generator shown in FIGS. 10 - 13, a process of forming the bubble generator 400 shown in FIGS.
18 10 - 13 will now be described. As shown in FIG. 15A, after having deposited a resistive material
19 such as TaAl over the silicon substrate 100, the resistive material is etched by photolithography to
20 form the bubble generator 400 and the parallel connector 401.

21 **[0046]** As shown in FIG. 15B, the individual signal line 101a is formed of a material having a high

conductivity such as Al on the parallel connector 401 by means of deposition and etching. As shown in FIG. 15C, the first insulating layer 601 is formed over the substrate 100. As shown in FIG. 15D, a contact hole 603 is formed at the middle portion of the bubble generator 400 by photolithography. As shown in FIG. 15E, a material having a high conductivity such as Al is deposited over the first insulating layer 601 and then etched to form the common signal line 101a' which intersects the bubble generator 400 and overlaps the contact hole 603.

[0047] As shown in FIG. 15F, SiN or SiO₂ is deposited over the substrate 100 to form the second insulating layer 602, As shown in FIG. 15G, partial etching is performed on the second insulating layer 602 and the underlying first insulating layer 601 by photolithography so that a portion of the end of the individual signal line 101a may be exposed. Here, the exposed portion is the electrode pad 101.

[0048] As shown in FIG. 15H, after having formed a film on the second insulating layer 602 by a thick-film forming process, the film is etched by photolithography to form the chamber walls 102c which extend parallel to the bubble generator 400 on either side of the bubble generator 400.

[0049] Etching techniques and film forming methods used in the above process are not described in detail. Of course, thin film growth and stacking and etching thereof, which are well known in the art, can be applied to the above process. In the ink-jet printhead according to the present invention as illustrated above, arrangement of a nozzle and a droplet generating structure associated therewith may be modified in various ways using the unit chambers and the bubble generator.

[0050] The ink-jet printhead according to the present invention can freely adjust the maximum amount of droplet ejected at one time within allowable range by controlling the interval between

1 both heaters of the bubble generator, while ejecting droplets having a stable and uniform size.

2 **[0051]** Meanwhile, according to the ink-jet printhead shown in FIGS. 2 - 4, ink is supplied to the
3 ink chamber on both short sides of the substrate. In addition to the structure, ink may be supplied
4 to the chamber by forming a through hole that extends parallel to the isolation wall at the middle
5 portion of two rows of the nozzles, that is, the portion adjacent to the isolation wall, or by removing
6 the isolation wall and forming a long through hole instead.

7 **[0052]** As described above, the ink-jet printhead according to the present invention is constructed
8 such that a unit chamber is provided for each nozzle and bubbles are generated chamber on both
9 sides of a nozzle within the unit chamber, thereby effectively preventing a back flow of ink while
10 facilitating adjustment of the size of ink droplet ejected through the nozzle. Furthermore, the ink-jet
11 printhead according to the present invention allows for high-speed and high-pressure ink ejection
12 with relatively low pressure compared to a conventional printhead. In particular, an ink channel
13 having a simple structure is provided, thereby avoiding the clogging of the ink channel due to foreign
14 materials while effectively preventing defectiveness of the printhead. Accordingly, the ink-jet
15 printhead according to the present invention allows ink droplets to be ejected with a quick response
16 rate and high driving frequency by virtue of the unit chamber and the ink feed channel.